Regional Sources of Toxic Chemicals in the Killer Whale (*Orcinus orca*) Food Chain: A Review

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Recently, high levels of contaminants, particularly PCBs, have been observed in southern resident Killer Whales (*Orcinus orca*). The risk of contaminant-related toxicity, coupled with declining prey abundance (salmon) and heavy vessel traffic, resulted in their recent listing as "threatened" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The origin of contaminants in areas frequented by resident killer whales, including Puget Sound and the Strait of Georgia, are largely unknown, since both regional and global sources contribute to contamination of these regions. In order to determine risk to killer whale health, we conducted a comprehensive review of existing information to identify the extent of regional contaminant sources. Although urban centers (e.g. Vancouver, Victoria, and Seattle) and certain industrial sources (e.g. pulp mills and mines), represent localized sources of pollutants, the Puget Sound basin represents a regional "hotspot". Consequent contamination of the marine food web likely contributes to contamination of the killer whale and may present a tangible risk to the health of this threatened species.

On the Trail of Common Murres in Puget Sound: Heading for Safe or Troubled Waters?

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In Washington State, Common Murres *(Uria aalge)* experienced a precipitous population decline in the early 1980s. Currently, the population remains at 30% of pre-1980 levels. The cumulative effects of predation, oil spills, dwindling food resources and fishery bycatch may prevent population growth, although the relative importance of each factor is unknown. We conducted aerial radio-tracking surveys of 22 Common Murres from Tatoosh Island, WA, in 1999 and 2000, to determine whether murres interact with a gillnet fishery active in Northern Puget Sound. As a first step, we describe the patterns of murre migration at the time of the fishery. After murres depart the Tatoosh colony, which lies at the confluence of the Strait of Juan de Fuca (SJF) and the Pacific Ocean, their initial movement is not random but rather is directed and at a large scale. They head east through the SJF, into Puget Sound (PS). After reaching the eastern SJF, directed movement ceases and becomes localized, two successive murre locations being no more than 20km apart. Of the murres effectively tracked, 82% were consistently located in the SJF and PS. Fourteen murres reached the eastern SJF and PS, and 71% resided within the confines of the same geographical area. Less than half (43%) of murres were located at least once within the boundaries of non-treaty commercial fishing zones. Murres may use SJF and PS because of the availability of predictable food resources and the apparently increased safety of calmer waters relative to the outer coast.

Salmon Farm-Pinniped Interactions in British Columbia: An Analysis of Predator Control, Its Justification and Alternative Approaches

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Predator control is widely practised in most forms of agriculture and aquaculture, including salmonid fish farming. Canada has a process whereby fish farmers can obtain authorisation to kill predators, particularly pinnipeds (seals and sea lions), but to date, this process, how it is being used by industry, and alternative measures to minimise the need for such killing have not been scientifically assessed. Here, we describe existing Fisheries and Oceans Canada (DFO) policy and hunting permit requirements associated with predator control; the impacts marine mammals are having on cultured fish production; the annual, seasonal and spatial pattern of kills; how this pattern is related to the abundance, distribution of haulouts and seasonal movements of pinnipeds; and the availability, effectiveness and use of alternate methodologies to deter pinniped impacts on fish farms. Establishment of Canada's Oceans Act in 1997 gave DFO the mandate for marine ecosystem management. With the recent growth in the coastal ecotourism industry and their interest in pinnipeds, there is now a need for this information. Pinnipeds are near the top of the marine food chain, and although they are not commercially exploited, their continued presence and occurrence in natural ecosystems at appropriate levels of abundance are important resource management considerations.

Status and Trends of Harbor Seal Stocks in Washington State, 1978-1999

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Abstract

Aerial, boat and ground surveys have been conducted of the coastal and inland waters of Washington since 1978 to determine the distribution and abundance of regional harbor seal (*Phoca vitulina richardsi*) stocks. Washington's coastal stock includes +150 haulout sites along the outer Washington coast from Willapa Bay to Tatoosh Island; the inland stock includes +200 haulout sites in the Strait of Juan de Fuca, San Juan Islands, Puget Sound and Hood Canal. Aerial photographic surveys were used as the primary census method and followed standard protocols. Surveys were conducted annually during peak pupping periods for each stock: June 1 to June 30 for the coastal stock and August 1 to September 30 for the inland stock. Counts were made of pups and non-pups hauled out during midday (0900 to 1500 hrs) low tides (+2.0 to -2.0 feet). A generalized logistic model was used to determine population trajectories and trends in abundance from 1978 to 1999. Washington's harbor seal populations are considered abundant and healthy, numbering in excess of 30,000 seals (coastal stock +15,000 seals; inland stock +14,000 seals). Population growth analysis using a generalized logistic model indicates annual growth rates of 6-8 percent for Washington's harbor seal populations over the last 20 years. Population growth for Washington's coastal and inland harbor seal stocks appear to have stabilized and are considered at or near carrying capacity.

Carrying Capacity Estimates for the Washington State Sea Otter (*Enhydra lutris kenyoni*) Population

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Carrying capacity (K) estimates for the Washington sea otter (*Enhydra lutris kenyoni*) population were obtained as products of the density of sea otters at equilibrium within a portion of their existing range and the total amount of available habitat. Sea otter habitat was classified during aerial surveys along the Washington coast in March 2000. Substrate type and kelp composition were characterized from the coast to the 40 m depth contour and sea otter habitat was classified as rocky, sandy, or mixed. Maximum foraging depths and maximum distance from shore were calculated for each of 68 sea otters radio-tagged between 1995 and 1999, and were used to approximate the offshore extent of sea otter habitat. The Geographic Information System software packages ARC/INFO® and ArcView® were used to calculate the area (km^2) and coastline (km) available to sea otters within each habitat type, and the offshore habitat use by sea otters. The most current population survey data (1996-1999) were used to obtain equilibrium densities of sea otters in rocky habitat in Washington. Because sea otters have only recently occupied sandy or mixed sites, the equilibrium densities for these habitat types represent a proportional density based on current counts in the rocky equilibrium region in Washington and available data from the California sea otter population. The Washington sea otter population is small and still growing, and population status relative to equilibrium density is uncertain. Consequently, the estimates of K are subject to change as more information becomes available.

Evidence Of *Brucella* Sp. Infection in Pacific Harbor Seals (*Phoca vitulina richardsii*) and California Sea Lions (*Zalophus californianus*) from Washington

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Blood samples were collected from harbor seals and California sea lions during capture operations in Washington, from 1994 to 1999. Positive or suspect titres to *Brucella abortus* antigen occured in 81 of 713 harbor seals (11 percent) and ten of 156 California seal lions (6 percent) captured. Since 1995, blood samples and tissues were also collected from stranded marine mammals and tested for *Brucella*. *Brucella sp*. was cultured and isolated from seven harbor seals from Puget Sound. *Brucella* sp. has been isolated from all lymph nodes and most body tissue and fluids (14 of 19). *Brucella* sp. isolates from Washington seals appear to be biochemically similar although genetically distinct to a strain isolated from a seal in the United Kingdom. Most affected seals were emaciated and had severe verminous pneumonia with intralesional *Parafilaroides sp.* lungworms. Some adult worms had large numbers of minute bacterial coccobacillus along the inner membrane of the uterus and within gut lumen. Immunohistochemistry revealed large quantities of an antigen within *Parafilaroides sp*., within cytoplasm of leukocytes in surrounding pulmonary parenchyma and affect lymph nodes. WDFW has begun screening marine mammals for evidence of *Brucella*. Harbor porpoise (five of 16) and northern fur seals (two of 5) had suspect or positive titres to *Brucella* antigen. Little is known of this new marine *Brucella* species. Though recent studies indicate that domestic livestock maybe infected by this strain.

Diet Of Harbor Seals in Hood Canal During 1998 and 1999

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The diet of harbor seals (*Phoca vitulina*) in Hood Canal was determined by scat analysis. Scat samples were collected during fall 1998 and 1999 and spring 1999 from haulout sites at Quilcene Bay, Dosewallips River, Duckabush River, Hamma Hamma River and Skokomish River in Hood Canal. Scats were rinsed in nested sieves and all hard parts (otoliths, skeletal structures, cartilaginous parts and cephalopod beaks) were recovered, identified to the lowest possible taxon and then sided and enumerated to determine minimum number of individuals for each species. Harbor seal diet was described by frequency of occurrence (FO). More than 20 prey species were identified from over 1100 scats, with Pacific hake (*Merluccius productus*), Pacific herring (*Clupea harengus pallasi*) and salmon (*Oncorhynchus* species) being the most predominant prey (>20% FO) of seals during the fall in both years. In addition to hake and herring, Northern anchovy (*Engraulis mordax*) and Three-spine stickleback (*Gasterosteus aculeatus*) were important prey species during the spring. Using all diagnostic structures (bones and otoliths) versus only otoliths to characterize diet varies in its importance based on the prey species consumed. Using the all-structures method is particularly important for identification of adult salmon. A comparison of the estimated number of salmon consumed based on scat analysis versus the estimated number of salmon consumed based surface observations indicates biases in scat analysis overestimate salmon consumption and/or less than half of the predations are directly observed.

Foraging Ecology of Harbor Seals in Hood Canal and the Potential Impacts on Threatened Summer Chum Stocks

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In the fall of 1998-2000, the Washington Department of Fish and Wildlife (WDFW) and Washington Cooperative Fish and Wildlife Research Unit began efforts to evaluate the potentially negative effects of predation by pinnipeds on the recovery of summer chum salmon runs in Hood Canal. Hood Canal has been the focus of these efforts because of the isolated nature of the system and the presence of abundant harbor seal (*Phoca vitulina*) populations along declining summer chum stocks. Surface observations were used to document harbor seal predation on returning adult salmon off the mouths of the Quilcene, Dosewallips, Duckabush, and Hamma Hamma river systems. Seals were observed consuming summer chum, coho, and fall chum in all three years. Additionally, steelhead, pink and chinook salmon were observed in 1999. During 1998 and 1999, 1017 (98: 601; 99:416) scat samples were collected at five haul-outs to determine food habits and provide additional insights into salmonid consumption. Key questions regarding nighttime predation rates and allocation of 'unidentified salmonid' predations to a particular species remain unanswered. Preliminary results suggest that harbor seals have the potential to negatively impact recovery of summer chum runs in those river systems with small escapements and habitat accessible to seals.

Summer and Winter Distribution and Abundance of Seabirds in Washington, 1996-2000

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In order to collect baseline data on the distribution and abundance of seabirds along the Strait of Juan de Fuca and outer coast of Washington, including the Columbia River estuary, Willapa Bay, and Grays Harbor, Washington Department of Fish and Wildlife (WDFW) conducted extensive at-sea surveys for seabirds, primarily within five km of shore, in the summers of 1996-2000, and winters of 1996-1998. These data were collected by methods that accurately measure observer effort as well as transect location. Therefore, bird densities can be standardized by effort and validly compared between treatment groups (e.g. location, year, season, month, bird species, water depth, distance from shore). Patterns of distribution and abundance of many species, and causes for these patterns (e.g. habitat correlates) will be presented. Summer and winter bird densities of species of concern (e.g., Marbled Murrelets and Common Murres) vary tremendously both spatially and temporally highlighting the fact that (1) population trends of seabird species are inherently difficult to accurately monitor, and (2) optimal sampling designs for monitoring different seabird species must reflect their respective differences spatial and temporal distribution and abundance.